DOCUMENT RESUME

ED 329 901 CS 010 451

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TITLE Ergonomics and Literacy: More in Common Than You Think.
PUB DATE 1 Apr 91
NOTE 27p.
PUB TYPE Guides - Non-Classroom Use (055) -- Information Analyses (070)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Human Factors Engineering; Individual Development; *Layout (Publications); *Literacy; Physical Characteristics; *Readability; *Reader Text Relationship
IDENTIFIERS Educational Issues; *Text Design; Text Factors; *Typeface

ABSTRACT

Ergonomics, or human factors, is the study of the relationship between people as functioning physical beings and the world in which they exist and this includes the textual material that they read. The presentation of textual material can be considered from two points of view: (1) the qualities of the text as impacted by the author; and (2) the qualities of the text as impacted by the format. This paper examines the influence of formal and textual organization as important factors in literacy achievement. Educators in general and instructional systems designers in particular need to be aware of these interactions between people and the material they read. An individual's interaction with the text is important: (1) to the individual, because it assists with job and academic success; (2) to educators, because it enables them to succeed with students who might otherwise be unsuccessful; and (3) with employers, because it reduces the time required for employees to read necessary texts. The ergonomics of literacy analyzes those physical characteristics which enhance a text's readability. Among the important physical attributes of a text are type face, type size, type emphasis, margin justification, line width, leading, and other vertical and horizontal spacing. By fitting the text to the reader, ergonomics can make more text understandable to more readers. The resulting improvement in the quality of the lives of individuals and to society may be invaluable. (Thirty-eight references are attached.) (SG)

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Elizabeth Worden

1 April 1991

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Elizabeth Worden

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Ergonomics and Literacy: more in common than you think.

Ergonomics, or human factors, is the study of the relationship between people as functioning physical beings and the world in which they exist, whether it is the world as nature created it or the world as people themselves created it. Ergonomics includes the relations between people and the machines they use, the surroundings which they inhabit, and the textual material that they read. It is as important to study the physical impact on the human body of the surface on which the body sits, of the tool which the human hand holds, or of the organization and presentation of textual material that the humán eye reads, as it is to study the differences in learning styles of individuals. Each has its impact on how the individual interacts with the learning task being presented.

The presentation of textual material can be looked at from one of two points of view. One can consider the qualities of the text as **impacted by the author**. As is well known, the creative textual attributes used by a writer affect the ease with which the text is understood. These choices include such characteristics as sentence length, word choice, multi-syllabic word density, active versus passive voice, accompanying graphics, embedded questions, complex sentence structure with dependent clauses, and the frequency of multiple-adjectival qualifiers. All have distinct influences on the ease with which a reader assimilates the information that the author is trying to convey. Or, one can consider the qualities of the text as **impacted by the format**. One can examine how the variables of formatting and textual organization can affect the ease with which a reader is able to access the information contained in the textual material. The scope of this paper is limited to the ergonomics of presentation. It will examine the influence of format and textual organization as very important facets in literacy achievement.

Is the ease with which the individual interacts with the text important? And to whom is it important? It is important to the **individual**, because it assists with academic and job success. It is important to **educators**, because it enables them to succeed with students who might otherwise be unsuccessful. It is important to **employers**, because it reduces the time required for employees to read necessary text, thereby reducing the cost of the engaging process.

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In a compelling paper discussing the value to industry of rapid accessibility of textual material by employees, Tullis (1983) examines the extraction of information from alphanumeric displays. His discussion is limited to computer-generated, monochromatic, and formatted displays as opposed to narrative ones. He points out that estimates for a Bell System computer system, the Automated Repair Service Bureau (ARSB), indicate that employees using the system must extract information from 344 million distinct frames (screens, print-outs) per year. Bear in mind that this was written in 1983, and that industry today is far more dependent on computers.

> The importance of designing these frames effectively becomes clear when one considers that if the ARSB users took only one second longer to extract information from each frame, an additional 55 person-years would be required just to extract the information. Can the design of such a display actually make a difference in how rapidly the user extracts information from it? ... After practice, mean time to answer a question about the display was 8.3 seconds for the narrative format and 5.0 seconds for the structured format - a statistically significant difference. That savings of 3.3 seconds per display translates to 79 person-years saved (Tullis, 1983, page 658).

If the same amount of work must be done, and one assumes $30,000 per person-year saved, this is $2,370,000 that the company does not have to spend, a savings directly attributable to conscious adherence to textual format considerations. This is a significant sum!

Educators in general and instructional systems designers in particular need to be aware of these interactions between people and material they read. Educators and educational researchers who are not aware of such interactions will be equally unaware of the experimental confounding which they bring to their work because of their inability to discriminate whether the learner has difficulty learning because of the organization of the lesson, the formatting of the text, the type of display, the placement of the monitor, the colors used, or the type of feedback given, among other considerations. They will not even know that these are questions which must be explored. It is only through an understanding of the interactions between people and their environment that professionals in the field of education can be sufficiently aware of the environmental factors which affect learning to effectively manipulate them.

The extent to which ergonomics is basic to the field of education is reflected in a recent publication of the National Society for Performance and Instruction (NSPI). This publication cites the following statement from the Credo of the International Board of Standards for Training, Performance, and Instruction:

> ...Performance technologists....systematically improve human performance through technologies of instruction, motivation, and **ergonomics** (emphasis added) to accomplish valid and appropriate individual and organizational goals.

Although the **ergonomics of literacy** may seem an unusual topic, it belongs to the field designated above by one of the major voices within the profession of Instructional Systems Design. It is a logical step to examine how the ergonomics of literacy, the physical presentation of textual material, influences the reader's ease of comprehension and improves human literacy performance.

The phrase **ergonomics of literacy** embraces a concept that is not new. In 1906, Dearborn recommended the use of certain line widths to enhance readability, recommendations which were not, apparently, based on substance, since more recent opinion is that these recommendations were made "on the basis of opinion and inadequate experimentation, and without regard to the use of leading" (Tinker, 1965, page 141). According to an early work by Tinker, "The Relative Legibility of the Letters, the Digits, and of Certain Mathematical Signs," at least ten reports on the relative legibility of capital letters had been published by 1928, and according to his 1963 survey, The Legibility of Print, experimental studies of legibility began to appear in the last quarter of the nineteenth century. Certainly, a century-long research interest in this area constitutes sufficient history to legitimize a concern that so few people are aware of the far-reaching consequences of their decisions about formatting.

Do such considerations really affect reading? To deal with this question, it is first necessary to define reading in order to determine what relation it has with the characteristics of the particular facet of ergonomics, formatting and textual organization, on which this paper is focused. Then it will be necessary to address the results so as to understand the effects of these considerations.

What is reading? On the surface, that seems a simple question. However, there is no general agreement on what reading entails. One can define it from the vantage of several viewpoints.

What do teachers consider reading to be? Haggard and Better observed teachers and found that when teachers assessed the effectiveness of student literacy levels, "Literal comprehension was the focus of a majority of teacher questions. Some inferential and open-ended questions were asked, but no one applied evaluative questions" (Hoffman, 1986, pages 137-138).

How do researchers in the field define reading? Calfee and Henry's model of reading includes the following four components:

- Decoding. The translation of the printed word into a pronounceable equivalent.
- Vocabulary. The assignment of meaning to a word, where meaning entails access to a network of associations.
- Sentence and paragraph comprehension. The "bottom-up" aspect of comprehension (Rumelhart, 1977) in which a relatively limited amount of text is parsed into a small number of functional units (such as subject, predicate, topic sentence, and elaborations).
- Text comprehension. The organization of a complete text according to one or more of the genres used to create texts (narratives, descriptions, sequential accounts, and persuasive writing) (Hoffman, 1986, pages 209-210).

The viewpoint held by those teachers and researchers cited above is that reading can be defined as an essentially behaviorist enterprise consisting of stimulus/response pairings.

This does not say much for the progress made in the field since 1965, when Tinker said that although many people feel that reading is getting meaning from the printed page, he considered this to be a misleading concept, because the printed page only contains symbols that stand for meanings, not the meanings themselves.

> Printed symbols as such merely stimulate one to recall some familiar concepts. That is, recognition of a word or group of words brings recall or arousal of previously encountered meanings. And any new meanings are derived from manipulation by the reader of recalled concepts, not from symbols as such. Concepts possessed by the reader are readily recalled. But when the concept is new, manipulation of related materials and meanings in the formation of the concept becomes a kind of problem solving (sic) process with emphasis on the thinking side of reading. In the full sense, reading is creative. It involves all the complicated mental processes activated in the interpretation of concepts and meanings that are aroused by recognition of printed symbols. What any reader derives from a printed page, therefore, is not exactly what some other reader would get or even what the author had in mind, but to a certain degree at least a personal re-creation on the part of the reader. Sometimes this process becomes highly creative (Tinker, 1965, page 5).

Almost thirty years ago, in 1962, Tinker and McCullough in Teaching Elementary Reading summed up their definition of reading in a concept that, despite its age, is thoroughly grounded in cognitive theory:

> Reading involves the recognition of printed or written symbols which serve as stimuli for the recall of meanings built up through past experience, and the construction of new meanings through manipulations of concepts already possessed by the reader. The resulting meanings are organized into thought processes according to the purposes adopted by the reader. Such an organization leads to modified thought and/or behavior, or else leads to new behavior which takes its place, either in personal or in social development (Tinker and McCullough, 1962, page 13).

How do contemporary cognitivists define reading? In Reading Difficulties, Instruction and Assessment (1988), Taylor, Harris and Pearson feel that they are expressing "a contemporary view of the reading process with an emphasis on metacognition and reader and text interaction" (page v). They define the process of reading in the following manner:

> Reading is a language process. It is closely linked to other language processes that children acquire: speaking, writing, and listening. Reading, like the other language processes, is a cognitive process. It is centered in the brain, and it involves all the processes that the brain uses in the normal course of mental activity: we pay attention, we perceive, we remember, we forget, and so on (Taylor et al., 1988, page 4).

Modern reading researchers have adopted schemata theories of cognition to explain how people read. "In the language of schema theory, the subject (reader) had to select a number of already existing schemata, or knowledge frameworks, as repositories for the information contained in...(a) specific text" (Taylor et al., 1988, page 12). During reading, readers control their processing in different ways. Some readers engage in schema-based processing, in which they use their own store of schemata to generate hypotheses about the text to be read. These hypotheses guide the processing of upcoming text and are confirmed or negated and therefore modified during the reading process. Other readers engage in text-based processing, which is much more passive. They wait for information from the text before they draw any conclusions. This type of processing is engaged in by less active readers. In addition, the more active schema-based processing readers use this passive control mode when an hypothesis has been negated, or when they cannot understand the sequence of events (Taylor et al., 1988, page 17).

Why is schema theory important in the study of reading? Schema theory enables reading theorists to explain problems with literacy development that could not otherwise be explained. Pearson and Spiro (1980) found that five kinds of reading problems can be explained within a schema-theory framework:

- schema availability — Students need to have well-developed schema available for a topic, or they will not understand selections about that topic.
- schema selection — If students have prior knowledge about a topic but do not use their available schema, they will have difficulty understanding selections about that topic.
- schema maintenance— Readers forget what they are reading about, and do not keep the appropriate schema in mind while they are reading. Sometimes this disjunction occurs because of "inconsiderate text," which does not make clear how different ideas in the text should be tied together.
- Overreliance (sic) on bottom-up processing — Students pay too much attention to graphic features and not enough to semantic features. They need to learn that reading should make as much sense as listening, and that comprehension sometimes requires going beyond the literal text.
- Overreliance (sic) on top-down processing — Students need to learn that sometimes it is essential to work within an author's schema, such as when doing an experiment, following directions, reading poetry, or doing evaluative reading (Taylor et al., 1988, page 18).

In sum, a distillation of current thinking about literacy seems to be that reading is a process during which learners engage in a sequence of steps, enabling them to:

1. interpret the literal meaning of the author's words. This includes decoding and comprehension.
2. Upon comprehension, assess the author's information and opinion, and
3. accept or reject the material as useful. Then,
4. integrate the material into their existing schema, which may involve simple assimilation, or may involve an unfreezing of existing ideational scaffolding and a refreezing of the integrated new form of the ideational scaffolding.

Even young children are thought to learn by the use of cognitive schema. Pearson and Camperell say:

> The research on children's comprehension of story structure suggests to us that from the outset of grade one, children ought to be reading stories that are highly predictable in terms of their conformity to canonical story schemata... We are convinced that it is these young children who need the predictability the most. Consider the case of a first grade student who is trying to make sense out of the unfamiliar orthography of English writing. The child is already confronted with one source of potential confusion (figuring out what sounds the letters make); to embed that task in a context that can be another source of confusion (stories that violate story schemata) seems to compound the problem (Guthrie, 1981, page 47).

Bearing this conclusion in mind, it seems clear that there is widespread benefit to be gained if textual material is made readily accessible from the point of view of comprehension to as wide a range as possible of potential readers with their varied levels of literacy achievement. The more accessible readers find the material to be, the greater the probability that they will be able to make the next steps in understanding and utilizing the material. How can material be made more accessible? There are a number of methods: some ways focus on the general population of readers and include assessing the literacy achievement of each individual reader, analyzing the specific literacy skills that each reader lacks and in which they need instruction, tutoring each individual reader in the literacy skills which they lack, and increasing the background knowledge of each individual reader so as to increase the richness of their existing schema; others focus on authors and include instruction and informational dissemination about literary methods that authors can employ to make the material they write more accessible to their audience.

Obviously, editors and printers whose products will be disseminated to a wide and varied audience can do little to affect the individual reader's approach to text, to alter the reader's existing schemata, or to coerce authors into employing effective literary techniques for increasing readability which are antithetical to the authors' style. However, they can have significant impact on readability by trying to avoid the production of "inconsiderate text." They can help readers to understand and incorporate into their individual schema the textual material that they are presenting. How can they do this? What qualities pertain to readability?

Jenkins and Pany are speaking of the textual and formatting attributes which influence the accessibility of material in the following selection:

> In our sense of the term, instructional practices for reading comprehension are those **factors external to the text which can be manipulated to influence comprehension and memory** (emphasis added) for it. Thus, such variables as advance organizers, pictures, or paragraph heads can be thought of as instructional variables... Not all variables that influence comprehension qualify as instructional variables, however. For example, story plot (Thorndyke, 1977), text organization (Meyer, 1975), and syntactic structures (Chomsky, 1972) are factors which influence the comprehensibility of prose,

> but they are not instructional variables in the sense in which we use this term. Passage characteristics such as those cited above definitely can affect a reader's acquisition of an author's message and can legitimately be considered instructional variables with respect to this intended message. However, since they are characteristics of a particular passage they cannot be manipulated without changing the paragraph itself (Guthrie, 1981, page 164).

Although Jenkins and Pany mention advance organizers, graphics, and paragraph heads, historically, those typographical attributes which "can be manipulated to influence comprehension and memory for (text)" (Guthrie, 1981, page 164) have been more basic and include font, legibility of letters of the alphabet, size of type, width of line, upper-case versus lower-case letters, and leading. Studies of such characteristics reach into areas as divergent as the physical shape of letters in a font and textual organization on a page. For instance, Ovink in "Legibility, atmosphere- value, and forms of printing types" (1938) made some useful suggestions for improving legibility of capital letters. These suggestions included:

- clear and simple definition of characteristic parts of letters, such as the curve at the bottom of J;
- avoidance of too narrow a width in forming such letters as A and V;
- refraining from use of extremely contrasting hairlines in obliques, horizontals, and verticals, as in Y, N, and F;
- avoidance of heavy and long serifs;
- avoidance of too close verticals in such letters as U;
- keeping bifurcation about halfway from top to bottom in such letters as M (Tinker, 1965, page 126).

Concern with the physical shape of a font is entirely appropriate: after all, if the reader cannot discriminate the letters, it is impossible for reading to take place. Assuming that the letters can be clearly discriminated, format attributes such as type face, type size, type emphasis (italic, bold, and all capital letters), margin justification, line width, leading, and other vertical and horizontal spacing arrangements have a profound influence on the ability of a reader to understand the material. All of these attributes can be chosen after the completion of the textual material, without affecting the grammatical, syntactical, and other choices that a writer makes, and fit unquestionably into the area of instructional practices for reading comprehension that are defined by Jenkins and Pany as being "factors external to the text which can be manipulated to influence comprehension and memory" (Guthrie, 1981).

What is known about the format attributes? Let's examine them singly.

Type face: The Paterson and Tinker study in 1932 reported on ten typefaces and their legibility. Of this group, they found five to be the most legible, as judged by speed of reading. These fonts were Garamond, Scotch Roman, Antique, Bondoni Book and Old Style. All five of these faces are serif fonts, although a sans serif and an old English style font were among the ten choices.

Tinker and Paterson, in "Differences among newspaper body types in readability" (1943), found that Opticon was the most readable of the nine newspaper typefaces that they studied. Opticon is a serif font.

In his 1964 Ph.D. thesis, "The effects of lower-case alphabet length, length of line and spacing on speed of reading 8 point Regal type," done at the State University of Iowa School of Journalism, Wiggins found that "slightly narrower letters in type fonts of shorter lower-case alphabet lengths increase speed of reading" (Tinker, 1965, page 171). Printers might not redesign fonts to reflect this finding, but they certainly can use such findings to help them select the fonts they choose.

James Hartley, in Designing Instructional Text, Second Edition, makes these suggestions for choosing type faces:

> In printing instructional materials the typefaces to avoid are of two kinds.
> 1. Those which may confuse the learner by exhibiting idiosyncratic features in the shape of particular characters or in the overall design of the character set; and
> 2. Those which may readily suffer loss of identity when printing or copying is less than perfect. Factors to be wary of in this latter connection are:
>   (a) fine lines which may break down;
>   (b) small internal spaces which may fill in;
>   (c) strong contrast between thick and thin strokes which may cause a dazzle effect, especially when the print is on very white or glossy paper; and
>   (d) letters which appear to touch one another, and which may actually run together if slightly over-linked or under-exposed.
>
> In general, instructional materials should be printed in characters which are firm in line, open and even in spacing and without idiosyncratic features in their design (Hartley, 1985, page 24).

To illustrate the influence that different type faces have on the ease with which a passage may be read, examples are presented below of a passage set in common serif, sans serif, and ornate type faces. All three selections are set at 10 point, with 2 point leading. The first is set in New Century Schoolbook, a serif face used in many elementary and secondary school textbooks.

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Next is Helvetica, a common and quite readable sans serif font:

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

The final font is Wartburg. Considered ornate by contemporary printers, Wartburg is reminiscent of fonts commonly used several centuries ago:

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Probably because of the nearly ubiquitous use of serif fonts in elementary textbooks and other elementary textual material, readers with poor literacy skills find serif fonts easier to read than sans serif fonts. Since readers with excellent literacy skills do not find it more difficult to read serif than sans serif fonts, there is little reason to avoid the use of serif fonts for the bodies of textual material. For contrast, and to visually separate titles from text, it is a good idea to put titles in sans serif fonts when the text is in a serif font.

Type size: It is important to recognize that although there is a tendency to consider type size as a constant, it is actually a variable. Different type faces of a given type size have different actual heights. In most cases the difference is not marked, but in others it is quite obvious. There is no way, unfortunately, to tell whether a type face of a given size is larger or

smaller than a different face of the same size without acquiring samples and comparing them. When discussing type size, therefore, it is assumed that faces of the same nominal size are of the same actual size, although this is an assumption that is more often invalid than valid.

Tinker and Paterson surveyed newspaper printing practices for 89 United States daily papers in 1935, and for 87 such papers in 1942. In 1935, most papers used 7, 7.5, or 8 point type. In 1942, more than a third of the papers still used 7 point type, and the others had shifted to 8 point. Since presumably a paper would not print in a point size that its readers found so small as to be unreadable, it seems safe to assume that of the range of readability, 7 point type constitutes a minimum size for legibility.

It might seem as though there would be little difference among types of three such similar sizes. To illustrate the legibility difference between text of these three point sizes, examples of each are presented below.

Here is a passage in 7 point New Century Schoolbook with 2 point leading.

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Here is the same passage in 7.5 point New Century Schoolbook, with 2 point leading.

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Finally, here is the same passage in 8 point New Century Schoolbook, with 2 point leading.

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Evidence of an upper limit of point size for readability was found in two studies done by Tinker and Paterson in the early 1940s: How to make type readable (1940), and "Influence of size of type on eye movements" (1942). These studies indicate that, when material was set in 6 to 14 point type, the 6, 8, and 14 point type were read considerably more slowly than the 9, 10, 11, and 12 point type. The slowness seems to be influenced by fixation frequency, pause duration, and regression frequency, which are increased for the smaller point sizes. For the 14 point type, although pause duration is decreased, fixation and regression frequency are increased. Readers indicated that they felt that the 10, 11, and 12 point type was most readable.

To help the reader visualize the difference that these point sizes makes in legibility, here are examples of a passage set in point sizes included in these studies, smaller (6 point), within (11 point), and larger (14 point) than the preferred range. First, here is a passage set in Palatino, 6 point, with a 2 point leading. This set is below the range considered to be easily readable.

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Here is the same passage set at 11 point Palatino, with 2 point leading. This set is within the range considered to be easily readable.

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

And finally, here is the same passage set at 14 point Palatino, with 2 point leading. This set is larger than the range considered to be easily readable.

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Type emphasis (bold, italic, and all capital letter use): Hartley cautions that young and less able readers may be confused by the change from regular type to emphatic styles, and need to be informed about the use of these typographic signals (Hartley, 1985, page 25).

Italic: Since 1923, when Starch stated that italic is read more slowly than ordinary lower case, many subsequent typography experts have considered that italic is far less legible than regular Roman lower case. Despite this expert opinion, italic is still used by writers and publishers to emphasize words, phrases, or sentences within paragraphs; for titles, headings, and citations within bibliographies; for some quotations; and for paragraphs or even pages within books. Tinker and Paterson, in 1928 with "Influence of type form on speed of reading," and in 1955 with "Prolonged reading tasks in visual research," consistently found that italic is read considerably more slowly than lower case, by about 5%. Readers do not like italic: 94% of the subjects in Tinker and Paterson's 1940 "How to make type legible" experiment felt that that it is much less readable than lower case. With this information available, it is surprising how frequently italic is still used, since there are other, more readable methods of emphasizing text. Tinker (1966) says "the use of italics should be limited largely to those rare occasions when added emphasis is desired or to brief headings in textual material" (Tinker & Paterson, 1966, page 135).

Hartley points out that italics were first used to pack more letters into the same space: "italic characters were introduced originally into printed books in the sixteenth century as a means of setting more characters to the line, the style of letters being more compressed than the vertically drawn and rounded forms of the normal lower-case character set" (Hartley, 1985, page 25). This effort to compress letters into space was hardly an effort to increase legibility! It is surprising that so many writers continue to interprete the use of italics as accomplishing the purpose of making particularly legible the most significant sections of their writing.

Following is a passage set in Bookman italic, 10 point with 2 point leading. The text of this paper is set in Bookman 10 point type, with 2 point leading, so this selection differs from the main body of this paper only in being set as italic face rather than plain face type. Does the italic achieve its purpose, that of emphasis? Hold the page at arm's length and see whether it appears visually emphasized.

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Boldface: Boldface is also used to emphasize text. In 1940, Paterson and Tinker found that about 70% of their readers felt boldface to be less legible. Although readers may feel that it is less legible, they read it with ease. There was no difference in speed of reading of boldface versus lower case type. Boldface is more visible than lower case. Boldface is an effective device for emphasis, since it "can be safely and advantageously employed without loss of legibility for contrast and emphasis" (Tinker & Paterson, 1966, page 136).

Hartley agrees and recommends that "If a change from the norm is really necessary, then the bold version of the lowercase letters can provide it without radically changing the geometrical characteristics of the word-image" (Hartley, 1985, page 25).

Here is a passage set in Bookman bold at 10 point with 2 point leading. Again, the passage differs from the main body of this paper only by the use of boldface. Contrast the boldface section with the preceding italic section. Both type styles are used to emphasize specific segments of text. Does one style seem to achieve this aim more effectively?

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

All Capital letters: In 1914, Starch reported that text in lower case was read faster than material printed in all capital letters. In 1928, Tinker and Paterson found that all capital text was read 11.8 % more slowly than lower case, and that nine out of ten adult readers considered lower case more readable than all capital letters. In 1955, Tinker, in "Prolonged reading tasks in visual research," found that all capital text retarded speed of reading as much as 9.5% to 19% from lowercase text.

Henney, in her study comparing the advantages and disadvantages of presenting textual material on CRT screens in mixed upper and lower case as opposed to all-capital letters, indicates that some differences exist between age-cohort populations and the interaction between speed and accuracy of reading all capital versus regular mixed print, but that the real interaction is between speed and accuracy (Henney, 1982, page 8).

The bulk of the evidence, therefore, consistently indicates that the use of all capitalized text should be restrained. Occasional use is not counter-indicated, but frequent use does impair legibility.

For comparison, here is a passage set in 10 point Palatino with 2 point leading with normal use of upper and lower case:

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Here is the same passage, set once again in 10 point Palatino with 2 point leading, but in all capital letters. Compare this all capitalized section with the boldface and italicized sections.

> NOW THE SONS OF JACOB WERE TWELVE. THE SONS OF LEAH; REUBEN, JACOB'S FIRSTBORN, AND SIMEON, AND LEVI, AND JUDAH, AND ISSACHAR, AND ZEBULUN. THE SONS OF RACHEL; JOSEPH, AND BENJAMIN; AND THE SONS OF BILHAH, RACHEL'S HANDMAID; DAN, AND NAPHTALI. AND THE SONS OF ZILPAH, LEAH'S HANDMAID; GAD AND ASHER. THESE ARE THE SONS OF JACOB, WHICH WERE BORN TO HIM IN PADAN-ARAM.

Margin justification: Hartley indicates that unjustified text is easier for less able readers to understand. He also suggests that the use of unjustified text can provide advantages beyond those of unexaggerated interword spacings.

> However, it is doubtful whether these experimental studies have considered fully all of the advantages of unjustified composition. One clear advantage of unjustified composition is that one does not have to fill up each line with text: one can consider (as with vertical spacing) where best to end the line.
>
> With unjustified text, for instance, it is possible to specify that no line should end with the first word of a new sentence, or that if the next to the last word on a line is followed by a punctuation mark then this last word could be carried over to the next line.

> (There is) an additional suggestion which shows how one can consider the starting as well as the stopping points in setting text of this kind. Research... has shown that readers prefer lists of items to be set out vertically (and possibly indented) rather than to run on in continuous text (Hartley, 1985, page 31).

These syntactic groupings undoubtedly aid the reader in their task of making sense when reading text.

The present paper is set with left justification only. For comparison's sake, here is a passage set at 9 point Palatino, with 2 point leading, with full justification:

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram. Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram. Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Notice the uneven spacing between words in this example, which degrades the reader's ability to spot and pause at syntactic groupings. This unevenness makes justified text difficult for poor readers, presumably because the uneven eye movements interrupt their reading.

Line width: Line length, called line width by printers, refers to the length of the line of text. It is traditionally measured in picas, which are units of approximately 1/6th inch. Therefore, a line of 24 picas is about four inches long, and would be referred to as a 24 pica line width.

The effect of the width of the line of text on legibility has been a matter of interest and diverse opinions for nearly a century. Dearborn, in The psychology of reading (1906), recommended quite short line lengths of 13 to 22 picas. This tendency to use short line widths continued until 1929 (Tinker, 1965, page 141). Tinker and Paterson conducted a series of experiments that used an analysis of eye-movement patterns to test the effect of line width on legibility. Basically, they found an interaction between leading, line width, and point size: when two point leading is used, the range of legible line width is rather broad, so that only very short line

widths of less than 9 picas, and very long line widths of more than 36 to 41 picas, depending on point size, decrease legibility as indicated by increases of fixations, pause durations, and regressions (Tinker, 1965, pages 140-142).

To help the reader understand the influence of line width, here is the same passage set at line widths that are inside and outside the optimal range.

First, the passage is set at a line width of 6 picas, shorter than the optimal range.

Now the sons
of Jacob were
twelve. The
sons of Leah;
Reuben, Jacob's
firstborn, and
Simeon, and
Levi, and Judah,
and Issachar,
and Zebulun.
The sons of
Rachel; Joseph,
and Benjamin;
and the sons of
Bilhah, Rachel's
handmaid; Dan,
and Naphtali.
And the sons of
Zilpah, Leah's
handmaid; Gad
and Asher.
These are the
sons of Jacob,
which were born
to him in
Padan-aram.

Next, the same passage set to a line width of 24 picas, in the middle of the optimal range:

Now the sons of Jacob were twelve. The sons of Leah; Reuben,
Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar,
and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the
sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the
sons of Zilpah, Leah's handmaid; Gad and Asher. These are the
sons of Jacob, which were born to him in Padan-aram.

The next passage is set at a line width of 47 picas, which exceeds the optimal range:

Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Leading: Leading is the distance between horizontal lines of print, the height of the space between the bottom of the print on one line and the top of the print on the subsequent line. In contrast to other typographical considerations which were considered important before 1926 (Tinker, 1965, page 145), leading was considered unimportant and was generally ignored. Even as late as 1940 (Tinker, 1965, page 145), most non-scientific magazines employed either no leading at all or used only one point leading. Paterson and Tinker (1940) performed a sequence of 11 investigations involving 11,000 subjects to determine the effect of leading on legibility. Their first experiment involved 10 point type set in a 19 pica line width. They determined that one point leading was no better than no leading from the point of view of speed in reading. Four point leading increased the speed somewhat, but two point provided optimal speed. Interestingly, readers felt that they read the fastest with this set. Paterson and Tinker finally concluded that it is not the leading alone that makes the difference in readability. Rather, it is the interaction between point size, leading, and line length that is crucial. To assist users of this information, they developed a guide that indicates safety zones of line length and leading for type of sizes of 6 through 12 points, stating that

> If the printer or publisher or editor is to cater to the preferences (judged legibility and pleasingness (sic)) of readers, he will employ a moderate line width with appropriate leading selected from those typographical arrangements within the zone of safety for that type size. Readers dislike very short and very long lines, as well as material set solid (Tinker & Paterson, 1965, page 147).

To help the reader understand the influence that leading has on legibility, presented below are examples of the same text passage set with varying leading. Notice the decrease in legibility that accompanies the decrease in leading.

Here is 10 point Palatino, a very common and readable serif font set 10 point with 2 point leading. This is an optimal setting.

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Here is the same passage, again in 10 point Palatino, set this time with 1 point leading:

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Once more, the same passage, this time, set solid in 10 point Palatino:

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

It might seem as though the inclusion of additional leading would increase legibility, but that is not the case, as the following example, set in 10 point Palatino with 8 point leading, will show.

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Other vertical and horizontal spacing: Hartley expresses significant concerns about spacing:

> Although the print is important — and clearly one cannot do without it — the clarity of this print can be enhanced by a rational and consistent use of the 'white space.'
>
> Space plays an important role in clarifying text. It is space that separates the letters from eachother (sic). It is space that separates the words from each other. It is space (with punctuation) that separates phrases, clauses, and paragraphs from each other; and it is space (with headings and subheadings) that separates the subsections and the chapters from each other....
>
> Many psychologists maintain that consistent spacing helps readers to see redundancies in the text, and thus to read faster; it enables them to see more easily which bits of the text are personally relevant for them; but, most important, consistent spacing aids readers' perception of the structure of the document as a whole and thus it helps them to understand its organization and structure (Hartley, 1985, page 27).
>
> ...units of line-feed (vertical space) can be used consistently in such a way as to separate out components of the text — such as sentences, paragraphs, sub and major headings. One simple way of using line-feed in this way is to use it in a proportional system. One can, for example, start each sentence on a new line within a paragraph (no extra line-feed); separate paragraphs by one extra line-feed unit; separate subheadings from paragraphs by two extra lines above and one below; and separate main headings from text by four extra lines above and two below... (Hartley, 1985, page 27).

An example of this use of line-feed to separate textual components is from Hartley, and is intended to be the bible selections for lay readers in church. The text is separated into syntactical sections. With this type of formatting, it is relatively easy to read the selection with coherency, compared with the difficulty in reading the common format:

Here is the common format:

> Now the sons of Jacob were twelve. The sons of Leah; Reuben, Jacob's firstborn, and Simeon, and Levi, and Judah, and Issachar, and Zebulun. The sons of Rachel; Joseph, and Benjamin; and the sons of Bilhah, Rachel's handmaid; Dan, and Naphtali. And the sons of Zilpah, Leah's handmaid; Gad and Asher. These are the sons of Jacob, which were born to him in Padan-aram.

Now, here is the same passage, making use of listed statements and syntactic line-endings:

> Now the sons of Jacob were twelve.
> The sons of Leah;
> Reuben, Jacob's firstborn,
> and Simeon, and Levi, and Judah,
> and Issachar, and Zebulun.
> The sons of Rachel;
> Joseph, and Benjamin;
> And the sons of Bilhah, Rachel's handmaid;
> Dan, and Naphtali.
> And the sons of Zilpah, Leah's handmaid;
> Gad and Asher.
> These are the sons of Jacob, which were born to him in Padan-aram (Hartley, 1985, page 32).

Hartley combines vertical spacing with a floating baseline, a concept that might seem rather novel to some. Here he explains what he means by this term, and why he considers it to make understanding of the text simpler for the reader.

> If the vertical spacing between the components of the text is to be consistent throughout the text, then this leads to the idea that the text should have what is called a floating baseline. This means, in contrast to traditional printing practice, that the text does not stop at the same point on every page, irrespective of its content. The stopping point on each page is determined by the content rather then by the need to fill the page.... It means that headings do not appear as the last item on a page, nor do paragraphs end on the top line of the next page. And, unlike traditional printing practice, the internal spacing of the text is not squeezed or expanded in order to make the text fit into a prescribed rectangle (Hartley, 1985, page 28).

The present paper is formatted with a floating baseline. It is hoped that this formatting characteristic makes it easier to read than it might otherwise be.

In the examples below, the latter format contains groupings which combine oceans with the geographic sections of the world in which these oceans are located. This grouping makes it much easier for the reader to grasp: since the format has grouped them together, the reader does not have to perform this task. How does this format make it easier for the reader? The answer is found in eye movement research.

> Eye movement research has told us a great deal about reading processes. The eyes traverse lines of text in jumps, or saccades, and it is in the pauses between the jumps that the text is sampled. Good readers make fewer (and bigger) jumps than poor ones, with less backtracking (or regressions) over the material that has already been covered. The more difficult the text, the greater the number of pauses and regressions. The evidence suggests that readers sample chunks of text which are largely determined by syntactic boundaries — and so making these boundaries clearer to readers is one of the procedures advocated by some writers as a way of simplifying complex text (Hartley, 1980, page 14).

This example of how much more readable text is with horizontal spacing setting forth segments of text comes from Hartley's "Space and structure in instructional text." Here is the material as originally formatted.

> ... Between Australasia and Africa is the
> Indian Ocean.
> These are the oceans of the middle parts
> of the earth. Round the north of the world,
> in the very cold areas, there is the Arctic Ocean.
> It is mostly frozen up, and the North Pole
> is in it. Round the southern parts of the world,
> around Antarctica, is the Southern Ocean...

Next, the material is formatted so as to use spacing that is grouping dependent. Notice how the difference in the ease with which the reader can determine which oceans are in the north, which in the south, and which in the middle of the earth.

> ...Between Australasia and Africa is the Indian Ocean.
> These are the oceans of the middle parts of the earth.
>
> Round the north of the world, in the very cold areas,
> there is the Arctic Ocean.
> It is mostly frozen up, and the North Pole is in it.
>
> Round the southern parts of the world, around Antarctica,
> is the Southern Ocean... (Hartley, 1980, page 131).

Hartley explains the significance of textual spacing in this way:

> spacing helps the readers to perceive redundancies in the text (and thus read faster); it enables them to perceive more easily the effective from the nominal stimuli (and thus focus on what is personally important); and most important, it aids their perception of the structure of the document as a whole (and thus helps them to comprehend its organization). To do all of this it is important that the space be manipulated in a consistent manner (Hartley, 1980, page 129).

It is hoped that by now, the reader has few questions about why it is important that the attributes of formatting and textual organization be considered and acted upon. It is important because the more easy we can make the process of reading, the greater the percentage of the population that will be able to fit into the world of today in an appropriate manner, and meet the needs that are expressed by Jeanne S. Chall when she speaks in her 1983 Stages of Reading Development:

> Universal literacy is a recent phenomenon, and it exists in only half of the world today. Up until about a hundred years ago, most people were completely illiterate.
>
> The growth in the number who are literate and in the extent and quality of their literacy can be appreciated in terms of the broad historical changes that social scientists see. According to many, modern civilization has gone through three great revolutions which human beings brought about and which in turn changed them **forever** (emphasis added) (Chall, 1983, page 142)....
>
> The problem of reading and literacy for today is that higher levels of reading are needed by more and more people in every country. The stage of reading development needed today to do the jobs available is the highest ever... (Chall, 1983, page 146).
>
> Some interesting questions could be asked. What happens, for instance, to those young people and adults who graduate from high school reading at the lowest end of the (reading) stage continuum... in a country that is predominantly at (much higher stages) (Chall, 1983, page 147).
>
> The general shift upward in reading achievement has caused problems for those who have been unable to meet these standards. The states are currently trying to require minimal standards (minimal competencies) for reading and other basic skills... It would be interesting to relate the numbers of young adults at different reading stages with the numbers of jobs requiring these levels of reading development. The relation between the two should show discrepancies in fit, and it might indicate the expected unemployment rates for those whose literacy development is too low.... Political and social surveys have found great differences among groups by educational attainment (Hayman, Wright, and Reed, 1975). The more educated are less violent, generally, more liberal in politics, and more tolerant of others' views. They also have higher incomes and their children have higher educational attainments.... What about those who do not and cannot reach (the same level)? Won't the gap be felt with greater pain, deprivation, and shame than in the past?... Special help will ease their problem, but it may not solve it altogether. Their feelings of incompetence can be severe, for in their own eyes everyone else does easily what they do with great effort (Chall, 1983, page 148 -149).

> ...learning to read is not like learning history. It is not disastrous to be doing poorly on certain historical periods in a particular grade. Reading is a complex skill, each level building upon the previous one, and most other learnings depending on it.
>
> Reading is pervasive in its influence and its effects, and when people fail in reading, it becomes a personal tragedy as well as a societal problem. Ironically, the number of reading failures is growing because more students stay in school longer and are expected to achieve more. When more students dropped out earlier, and when jobs were available for those without diplomas, poor readers suffered less. But **that time is gone** (emphasis added) (Chall, 1983, page 165).

Ergonomics and literacy may at first have seemed an unlikely pair. However, by judicious use of those format attributes known to help the reader to understand text — in other words, by fitting the text to the reader — ergonomics can make more text more understandable to more readers. And that is, after all, the aim of printed material, to be legible to the user. If through the use solely of formatting methods, more text can be more easily read by more people, the improvement in quality that may be added to the lives of the individuals doing the reading as well as to society cannot easily be estimated, and may be invaluable.

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